4.5.2.

4.5.3.

4.6. DOCUMENT/INFORMATION RETRIEVAL

Project CHIVE is the large scale document/information retrieval system under development in the Agency. To date computers have been used to support experimental work on

this project. The amount of such computer time has varied considerably from month to month. One segment of the total computer-driven CHIVE system will be implemented initially. It is estimated that 15 hours of 360 mod 67 computer time be required monthly by 1967.

4.7. LANGUAGE PROCESSING

The automatic Language Processing (ALP) System, currently under development by IBM, is scheduled to be installed in the Agency by October 1965. The initial system will consist of special purpose hardware interconnected to a 1401 computer. Its two modes of operation will a) perform stenotype machine shorthand transcription to English and b) perform machine assisted translation from Russian to English. If proven successful, the special purpose ALP hardware will be interconnected with the planned major computer system. The estimated 360 Mod 67 time required per month is 8 hours.

# Chapter 5.

# PROPOSED SYSTEM

## 5.1. SYSTEM 360 HARDWARE

In April, 1964, the IBM Corporation announced a family of computers known as System 360. At the time of announcement five different models were announced. Each of these five models was to have exactly the same logical structure, instruction set, and options. The five machines differed in speed and price. The Model 30, the low end of the scale, was the slowest and least expensive. The model 70, the high end of the scale, was the largest and most expensive. These machines bracketed the performance range from the 1401 size machine to a machine somewhat larger than the 7094-II. In addition to their common design, the machines were fundamentally unique for two reasons. First, they were a compromise design which would accomplish both business data processing and scientific computing on one computer with an acceptable throughput per dollar. Second, they had a unique instruction format which was economical in terms of core storage, and which allowed large core memories to be directly connected and addressed in a straightforward manner.

Since the original announcement, two more machines have been added to the series. The Model 20 is a small computer

with price and performance below the Model 30. It is a cousin to the Model 30 in that programs prepared for the Model 20 will run on the Model 30, but not conversely. At the extreme high end of the line, the Model 92 was announced. The Model 92 is bigger and faster than either the Stretch, the Larc, or CDC's 6600. It is completely compatible with the remainder of the line with the exception that the commercial option is not available for the Model 92 since it is primarily intended for heavy scientific computation.

In the 15 months since announcement, improvements have continued to flow from the design laboratory. One machine has had its memory cycle time reduced and is being offered with the faster memory at the original price, thus increasing its throughput per dollar. The Models 60 and 62 have been discontinued, and are replaced by the Model 65, faster machine at a lower price. New input/output gear has been announced and additional devices are rumored. A special configuration, the Model 67 has been announced to satisfy the market demand for a machine to support remote consoles, time-sharing, and a commercial machine which will allow dynamic reconfiguration for those installations which require high availability at a reasonable price.

5.1.1. Introduction to System/360

System/360 is a stored program, general purpose digital

computer with unique capabilities. The same design is implemented in a series of CPU's to offer a range in speed and performance. The various models are each constructed from a family of new circuits called SLT (Solid Logic Technology). These SLT circuits are the result of several years circuit development which has resulted in a series of integrated digital circuits which can switch their logic states in ten to thirty nanoseconds (billionths of a second). To exploit the productive capacity of this new family of circuits, IBM has implemented the S/360 CPUs so that the smaller machines use the same family of circuits but merely work them harder. This is most clearly seen in the width of the bus to memory. The bus on the Model 30 is only 8 bits wide. Thus, it has an 8 bit adder and performs arithmetic 8 bits at a time. As the models increase in speed, the width of the memory bus grows 8, 16, 32, and 64 bits wide.

As indicated above, the design of S/360 was chosen to allow the attachment of large capacity memories. In previous designs the number of address bits in a computer instruction had to be sufficient to allow the largest core memory contemplated to be addressed. In S/360, register addressing is used so that the instruction length may be held to a minimum. The actual memory address to be referenced is held in one of six-

teen general registers. When the instruction is fetched, a four bit field in the instruction points to the register which holds the address of the memory cell to be referenced. The registers are 32 bits in length, the address portion is 24 bits long. Using this scheme, a net saving of 20 bits per instruction is possible on the larger configurations. The 16 general registers are also used for arithmetic registers and subroutine linkages.

Some instructions also carry a 12 bit modifier field which allows an offset to be added to the register address immediately preceding the memory reference. These 12 bit fields allow an amount of conventional direct addressing limited to the first 4096 bytes of memory.

The memory itself is organized around the eight bit byte. Each eight bit field has a unique memory address and can be selected, along with one or more contiguous bytes, at the time of an instruction execution. Although each byte is uniquely addressable, a performance penalty is extracted in the event a programmer elects to fetch bytes or strings of bytes which do not start at a natural memory division (8, 16, 32, or 64 bit word boundaries).

The instruction sequencing and interrupt provisions within S/360 embody a large portion of the best design features

historically found to be useful for communications and real-time installations. A mask register is provided which allows the various interrupt conditions to be selectively enabled. When an interrupt has been enabled and the interrupt event occurs, the instantaneous status of all critical registers is stored and the execution of a new stream of instructions is initiated. The conditions stored at the time of interrupt allow the previous instruction stream to be resumed after the immediate processing associated with the interrupt is completed. The various CPU registers are stored into a single formatted word called the Program Status Word (PSW). The special history word so assembled allows the minimum interrupt time to be reduced so that the large interrupt time penalties, associated with some previous machine designs, are not experienced.

The instruction repertoire has the normal complement of instructions to facilitate fixed-point arithmetic, address modification, testing, and sequencing. A commercial instruction set is provided as an option which allows the CPU to perform variable field length decimal arithmetic, and to expeditiously accomplish certain packing and editing functions found in commercial data processing work. A second option, the scientific option, provides additional registers and circuitry to perform floating point arithmetic on either 32

or 64 bit operands.

The fundamental architectural design of S/360 encourages multiprogrammed operation. Three features are responsible for this flavor. First, the CPU embodies the concept that a monitor program is mandatory. As such, there are certain functions reserved to the monitor and only to the monitor. These functions are program switching, accounting, interrupt handling, and all I/O. The instructions to accomplish these functions are called privileged instructions and they cannot be executed by an applications program. A control circuit is set to determine whether the machine is operating in the problem state or the monitor state. Any attempt to execute monitor functions in the problem state is interpreted as an error which initiates an interrupt and calls for monitor action.

To protect the monitor and to protect applications programs which may cohabit in the same core memory, storage protection feature is provided. The monitor assigns each applications program a storage protection key. Whenever a memory reference (either fetch or store) is made, the key associated with the program initiating the action is automatically compared with the lock mechanism associated with that block of core memory. If they match, the memory reference is allowed with no performance penalty. If they disagree, the instruction

execution is terminated and monitor intervention is requested. Thus, two or more applications programs can be protected from each other so that their information is held invoilate. Similarly, the monitor can protect itself from both of these applications programs.

The third feature which facilitates efficient operation in general and multiprogramming in particular is the multiplexing channel feature. Two types of channels are offered on S/360: the selector and the multiplexor. The adjective "selector" is used to specify the traditional type of I/O channel which, when once initiated, can sustain only one I/O operation at a time. In short, it is dedicated to a specific device from initiation to completion. These we have long known and can be considered traditional. On the other hand, the multiplexor channel contains additional registers and control circuitry to allow the data path to be time-shared by several relatively low speed I/O devices on a demand-priority basis.

In any input/output operation, registers must hold the address of the next memory cell to be referenced, the total number of bytes to be transferred, and certain control information associated with the I/O operation itself. A multiplexor channel has a set of these registers for every attached device. A typical channel may have up to 128 sets. When an

operation is started, the registers are initialized and the first memory reference is made. From then on, whenever the device demands (or allows) service, the appropriate set of registers is fetched from a local memory and used to route the next byte to or from main memory. Such a channel is extremely well suited for handling concurrent operations on several slow speed character-oriented devices such as teletypes or remote terminals.

The multisystem features allow two or more CPUs to be connected in a multiprocessing configuration. These provide for CPU to CPU communication, memory priority and tie breaking, a master-slave relationship, and limited types of automatic reconfiguration and recovery in the face of hardware or software malfunctions.

5.1.2. I/O Device Survey

The very flexible channel arrangement on S/360 allows a variety of devices to be connected via multiplexor or selector channels to a CPU whose speed and storage characteristics support their operation. The interface between the channel (either multiplexor or selector) and the control unit is well defined. If manufacturers of special purpose equipment merely meet this channel interface spec, they can directly connect to a 360 channel with no additional hardware or special purpose

circuitry. Thus, it is highly probable that other manufacturers will provide device gear to complement IBM's offerings. However, while this is highly probable, the breadth of IBM's offerings is impressive. A sampler of such devices is provided below.

The IBM 2361 core storage unit can either be used as an extension of memory, or as an I/O device. One or more of these devices may be attached which provide independent access to a 64-bit word double every eight microseconds. Each bulk storage unit will contain 1,048,576 bytes of storage, each nine bits (eight data bits plus one parity bit) wide.

In the domain of rotating storage devices, IBM provides the 2302 disk storage, the 2311 disk storage, the 2321 data cell drive, the 7320 drum storage, and the 2301 drum storage. In addition, they have recently announced the 2314 multidisk. These devices are graded in total capacity, access time, rotational rate.

In the more traditional department of tape drives, they offer five, ranging from the 15 kilobyte 2415 unit to the 340 kilobyte 7340 hypertape unit. While the drives are normally the nine track tape, a seven track compatibility option is also available.

In I/O gear, they offer two card readers: 1402 and the

1442; a punched paper tape reader; an optical mark reader; two magnetic character readers; two optical readers; and four line printers including the 1403-3 which prints at 1100 lines per minute and also provides the interchangeable train cartridge feature. They provide the 2702 control unit which is the interface to the common carrier, and data collection consoles, data communication consoles, terminals, process control attachments, and two versions of CRT displays. To round out the assortment, the graphical display gear, developed in conjunction with General Motors, provides the capability to produce engineering drawings on-line and photograph them for later reuse.

5.1.3. Model 65 Plans

OCS plans to install an IBM model 65 mono-processor in the first quarter of 1966. This machine will have 524,288 bytes of storage with a cycle time of 750 nanoseconds per eight byte word. The configuration planned is shown in figure 1. The single shift monthly rental is $70,000.

The configuration shown is more readily appreciated if it is analyzed by the subsystems and projects it supports. A central CPU-memory-storage complex is provided to support all projects. It consists of the Model 65 processor and its two interleaved core memories, the operator's console, limited on-

# IBM SYSTEM /360
# MODEL 65 - MONOPROCESSOR

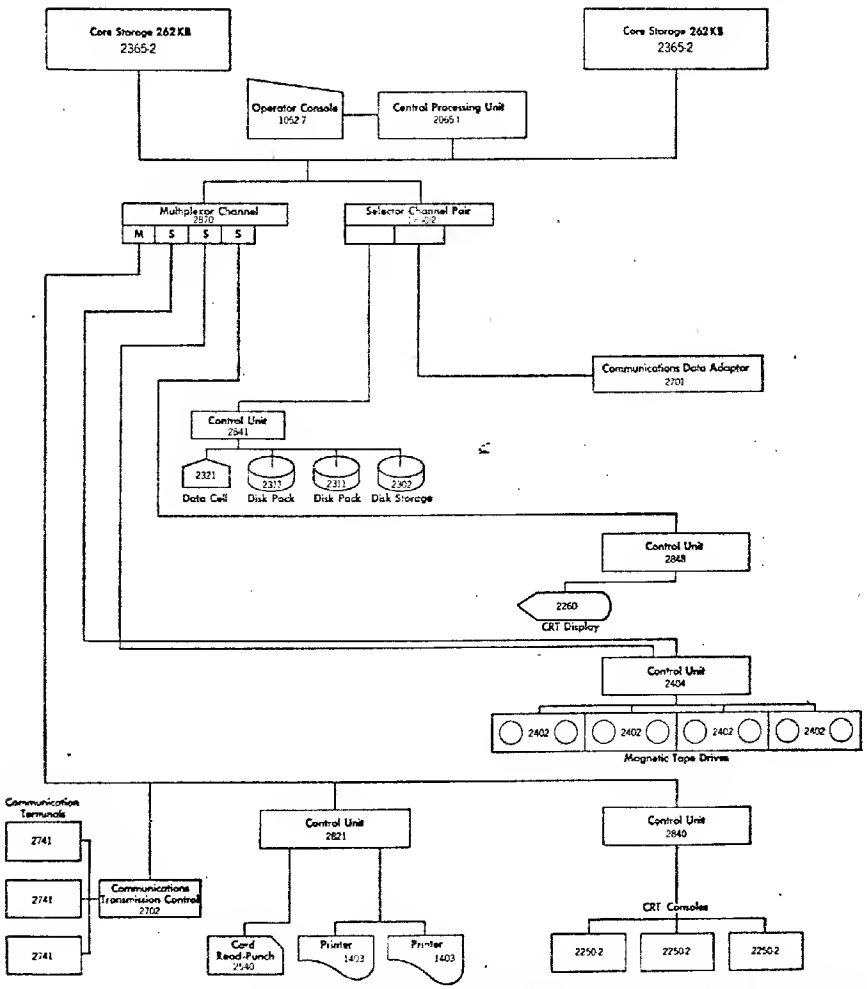



FIGURE 1

line card reading and printing capability, 8 magnetic tape units, and a 2311 disk file for programming systems residence. This is supplemented by a second 2311 for applications program residence and a 2302 disk file for on-line storage with intermediate access and capacity.

Just this much equipment is a very powerful monoprocessor capable of multiprogramming. Jobs and their data may be introduced to this system via an off-line card-to-tape machine, or via the on-line card reading equipment. Output may be taken on-line or written on tape for delayed printing.

To this central processing system, three 2741 terminals have been added to allow the central system to be queried via communication lines from remote terminals not necessarily located in the Headquarters Building. Further, three 2250 CRT terminals have been added to allow the computer's files to be queried and manipulated from the high speed CRT terminal displays located within the Headquarters Building. In order to provide the additional storage necessary for holding files for inquiry and display, the 2321 data cell storage device has been added. This one data cell has the capacity of 400 million bytes.

The third set of devices added to the configuration will allow the direct attachment of the Univac 1004 data communications net and provide an entry point for our special

purpose

This Model 65 is an interim system which will allow us to convert and process the programs now running on four of our five computers, will allow us to start building the large file on the data cell, and will provide an experimental facility so that we may become experienced with the idiosyncrasies of two types of remote terminal devices.

To prepare for this interim system, an IBM Model 30 will be installed in August 1965 to replace the IBM 1401 now performing yeoman service: printing tapes and reading cards. A multi-task utility program is being prepared which will cause the Model 30 to process tasks concurrently as required by operator action. In addition to this yeoman service, the early installation of the Model 30 will allow us to perform these other functions. Since the Model 30 will have both 7 track tapes and 9 track tapes, the file conversion and translation outlined in Chapter 8 can be initiated. Second, the training of programmers on System/360 can be started. The Model 30 operates identically with the Model 65 in every way except that it does not have the variety of I/O gear and terminals and it is slower. However, for programmer training, these are not serious limitations. Third, the programming systems outlined in the sections to follow can be experimentally operated, checked out, and modified by the systems programming

group in advance of the time when they will be necessary.

5.1.4. Model 67 Plans

In the first quarter of 1967, the Model 65 CPU will be removed and additional equipment will be installed to make the resulting configuration conform to the schematic in figure 2. In addition to the twin CPU's each with its own preferred pair of high speed memories, additional I/O gear has been added to provide for the growth in services, both on-line and batch, presently anticipated. In addition, a pair of IBM 2846 I/O controllers are added between the channels and the memory bus. These controllers, and the related CPU hardware, were designed for communications-mode time-sharing operation. They provide the dynamic relocation capability thought to be very valuable for this type of operation.

Before the Model 67 with the twin CPUs is installed, communication-mode time-sharing will undergo further evaluation so that the costs and benefits may be evaluated. At the present time, the OCS plans call for the installation of this hardware as a means of raising the availability of the system to those who require remote inquiries.

In any large complex data processing equipment, hardware

components will occasionally malfunction and these malfunctions may require a significant period of isolation and repair. Using the hardware shown on the schematic, isolation switches may be thrown, either automatically or manually, to disconnect a malfunctioning unit and allow the remainder of the system to survive. These switches are an integral portion of the time-sharing hardware option. They allow a properly designed software program to dynamically reconfigure the hardware connections so that the failing unit is isolated. The software may then proceed to re-evaluate priorities for work outstanding and to allocate the remaining processing power to those tasks considered most urgent. This is a limited form of fail-soft operation which will allow all single hardware failures to be absorbed and some triple hardware failures to be absorbed before the system becomes unavailable to all users.

As our computer systems lose their more traditional guise and become a more direct and accessible tool to operating management, availability will be a more critical requirement. A system planned in mid '65 will be installed in mid '67 and should be operating smoothly by Christmas, 1967. This extended development cycle is due to three reasons. First, the hardware and software are not available from the

# IBM SYSTEM /360
# TWIN MODEL 67 CPU-MULTIPROCESSOR

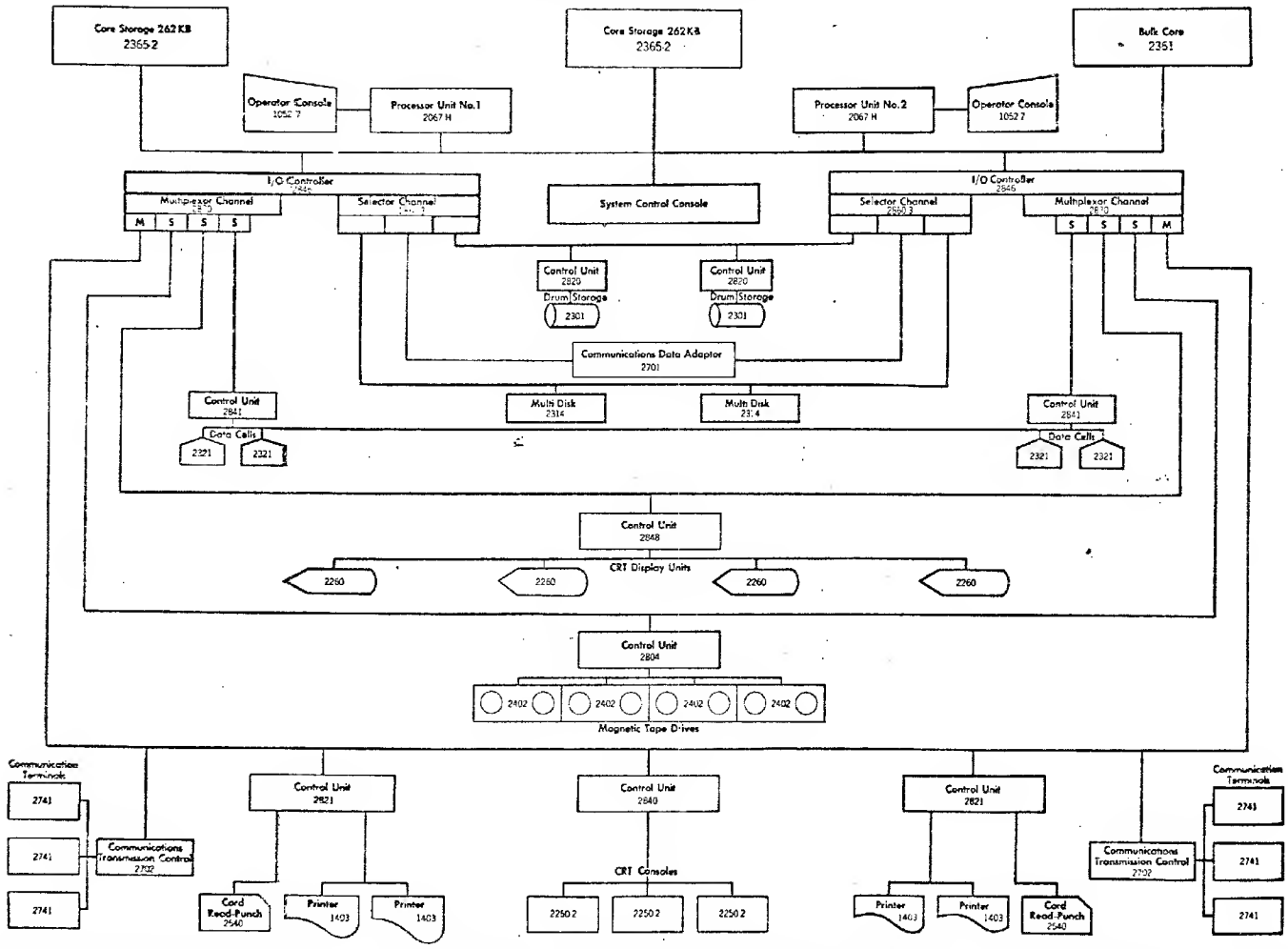



FIGURE 2

vendor until late '66 or early '67. Second, the programming staff is highly compartmented and not totally acquainted with these concepts (they have no experience with this type of operation). Third, even though the hardware, this program, and the staff training were completed and ready, the large data files must be meticulously edited, properly structured, and stored to support such an on-line operation. These files do not now exist in the proper form, and their development is a significant undertaking.

## 5.2. SYSTEM 360 SOFTWARE

The software provided for System/360 consists of one all-encompassing integrated design implemented in a modular fashion. IBM's distribution agency will provide the software modules requested on magnetic tape. Our systems programmers and the Systems Engineers from IBM will familiarize themselves with the documentation related to the modules requested and, when the tape is received, prepare for a process known as Systems Generations.

Control cards will be prepared and test problems selected. The SE's and systems programmers then will visit IBM's local data center and perform actual SYSGEN. This is a multitask process which results in a customized operating system for our machine. If the newly generated system does not require

hardware which is unavailable at the service center, the system may be tested immediately upon generation. However, if the system requires a unique hardware configuration, it can only be tested at our facility. The resulting operating system consists of a control program and several libraries.

The control program contains only the features selected and the libraries contain language processors to translate the various source languages into load module form.

The control program operates in the supervisor state and performs all I/O, scheduling, interrupt handling, and storage protection. All other programs operate in the problem state. This is true be they applications programs or vendor supplied language processors. Thus, to the control program an application program which determines optimum trajectories appears just like a language processor program which translates FORTRAN IV into load module form.

5.2.1. Language Processors

IBM will provide processors for four different languages. Each language processor has one or more design levels. For example, two FORTRAN processors will be provided. They both operate under the operating system, and they both translate the full language from source to load module form. However, one of these is implemented to accomplish this translation using several overlays, none of which is larger than 10,000

bytes. The other design fits the entire compiler into 200,000 bytes of memory. These offer the user the option of multi-processing, where one processor may be the compiler, or mono-processing to gain speed. Similar compromises are offered for the other source languages.

5.2.1.1. Assembly Language

The assembly program for S/360 operates under Operating System/360 and translates programs in source language form to a form suitable for the Link Editor. The assembly is of more or less traditional design which translates symbolic instructions with mnemonic operation codes into a compressed symbolic form required by the Link Editor. The assembler encompasses the best features from the MACRO forms found in the 7010 Autocoder and the 7090 MAP languages. The expected variety in data representation, address calculation, and applications program sectioning are all provided. The assembler provides the usual program listings and error indications as a by-product of the assembly process. The assembler references no libraries, but translates each module presented on a module by module basis. The output form goes to the Link Editor which resolves inter-module symbols, includes library routines as called, and outputs a relocatable program in load module form suitable for loading into core.

5.2.1.2. FORTRAN

The specs for the FORTRAN provided under Operating System 360 are a superset of the specifications used for the FORTRAN IV compilers now in existence on currently operating equipment. The language and the constructs currently allowed are similarly allowed. However, certain arithmetical differences may result due to the difference in word length between current systems and S/360. Many of the programming restrictions common to current FORTRAN IV have been relaxed in the 360 version. In addition, additional capability has been added in the form of variable attribute control, adjustable array dimensions, and several new codes for formats, I/O lists, spacing, and literals.

5.2.1.3. COBOL

Operating System/360 COBOL is not completely compatible with any of the COBOLS now operating on current equipment. Each of the current COBOLS was designed to effectively exploit one or more current computers. Therefore, they were not completely machine independent. Rather than perpetuate these difficulties, Operating System/360 COBOL cleans up and purifies many of these language constructs, plus providing new language constructs necessary for asynchronous data processing in a multiprogramming environment. An additional program is provided called the COBOL Language

Conversion Program (COBOL LCP) which will translate, where possible, from the constructions presently used in current COBOL programs to the equivalent construction in 360 COBOL. Where translations are impossible, the section of code will be flagged for programmer review.

5.2.1.4. PL/I

In parallel with the development of System/360, a new software design effort was initiated in an attempt to devise one programming language which would be suitable for scientific and engineering calculations, business data processing, and real-time operation. Further, it was decreed that the language should allow and exploit direct access storage devices such as drums and disks, remote terminals, and the dynamic features provided by the control program and the hardware interrupt scheme. To accomplish this assignment, a joint design team was set up consisting of employees of IBM and volunteers provided by the scientific computer users group, SHARE. The first report was published in mid-1964 and has undergone several revisions since then. Superficially, this effort looks like a success and when compilers for the language are available, a detail evaluation will be made.

The adoption of a single programming language, single control program, and single computing system has considerable appeal to those of us who manage a large work force of pro-

grammers working on a variety of assignments in a highly fluid environment. Training is simplified, personnel scheduling and assignment problems are eased, fewer systems programmers are required for trouble shooting and maintenance, and the efficiency of the entire machine room operation is improved. If these advantages can be accomplished with little or no additional costs and if the manufacturer provides language conversion programs to translate from System/360 COBOL and System/360 FORTRAN into PL/I, then the language will undoubtedly be adopted for standard use throughout the Center.

5.2.2. Control Programs

As mentioned above, one integrated control program design was set down and then optional features were provided to support different hardware configurations or modes of operation. One large set of these pertains to Data Management.

Data files can be organized to reside on magnetic tape, disk, or core memory. Furthermore, they may be written once and read many times, constantly undergo update and change, accessed in the same form and sequence as they are updated, or maintained in one form and referenced in yet another sequence and format. These options, combined with the physical specifications for the various disk devices, tapes, and memories, require a series of subprograms to be devised called "access

methods". Additional access methods are sure to come as new devices are developed and made available.

Other control program options concern a choice of operational modes. Data can be batched on a peripheral machine and presented to the central processor as a series of sequential tasks with uniform priority. This, of course, is the traditional mode of operation. Further, data can be presented to a single processor as it becomes available so that the processor may reschedule its outstanding work and adjust its queues between each processing task. Other options are available which allow multiprogramming and two or more processors to perform multiprocessing with fixed or dynamic functional assignments. All of these options are available in the one design. The System Generation function will cause combinations of these modules to be selected to support our operations.

5.2.2.1. Serial Tasking Operations

The first version of operating System/360 to be employed by OCS will be a simple serial tasking, batch-operated system. This will be system generated for the Model 30 configuration and will be used for training system programmers, for verifying the operation for the several language processors, for converting files, and for checking out converted applications programs.

This operating system will also be used to perform SYSGEN for subsequent operating systems, and to check out modifications to the IBM supplied control programs as required by unique conditions existing within OCS. A second version of this serial tasking system will be used for the first several months on the Model 65 after initial installation in the first quarter of '66.

5.2.2.2. Multiprogramming

A multiprogramming operating system will be generated in the third quarter of 1966 for the Model 65 configuration. It will provide for Assembly, FORTRAN, and COBOL source languages. It will be based on the teleprocessing version of OS/360 and will support a limited number of remote consoles. It will encompass access methods for files on magnetic tape, disk and data cell. The preparation of this operating system will not be a trivial task. The manufacturer's offering provides most of the features needed although special modules will need to be prepared for the non-standard analog to digital inputs and the Univac 1004. The accounting provided by the vendor will need to be reviewed so that we may distribute costs to our various users on the basis of usage even though we are operating in a multiprogramming mode. In addition, we must completely review the manufacturer's provisions for

edly will find them lacking and, while their provisions will be a useful base, we will be forced to provide additional functional capability to handle our own unique security needs.

5.2.2.3. Remote Retrieval

After the multiprogramming system is operating well and we have become familiar with the hardware and software provided to support remote console operation, it is anticipated that we will have to design one or more additional access methods to allow remote inquiry, in-process interrupt, high priority service, and immediate response for the terminals that we decide to support. It is anticipated that these modifications will take place within the confines of the design of OS/360, but they will be undertakings of significance occasioned by the unique requirements of the Agency.

5.2.2.4. Twin Processor

The IBM software to support the twin Model 67 configuration is now in the process of being specified. As indicated above, the Model 67 is in our plans as the best way to achieve the processing capability we will require in the 1968-72 period. Preliminary specifications for the multiprocessing monitor system are available, and they appear to be in substantial agreement with the Agency's needs. As a minimum, this software will have to be adapted to the Agency configuration

shown previously. In addition, any especial provisions we have incorporated for accounting, security, accountability or retrieval would necessarily have to be incorporated into this software design also. As more details become available on this software, continued study of the specifications will be necessary in order to determine the necessary additions to satisfy the Agency's need.

5.3. ANTICIPATED PROBLEMS

In reviewing the IBM supplied software and in becoming acquainted with the IBM provided hardware, three major problems have been defined which will require study, solution, and management approval before the plan outlined above can be completed. These problems are briefly sketched below.

5.3.1.

Page 89 deleted.

5.3.2. Audit Trails and Accountability

The "new wave" in computing is on-line operation. Some of the proponents of this mode of operation have hypothesized that all computing will be on-line in the next few years. Several major obstacles must be overcome before such a system is possible. First, some of our data comes from such widely spread locations that it must first be concentrated before it is entered into the computer. For these data, accuracy is more important than time and the traditional keypunch and verifying process provides high accuracy combined with low cost. In the foreseeable future a good portion of our data will be entered into the machine in this way.

Another facet which will impede the predictions concerns the capabilities of the average trained programmer and his usual work habits. During the process of programming a task, a large job requires access to 20 to 50 different pieces of paper. The current mode of operation spreads these pieces

of paper all over a large desk where they are instantaneously available for ready reference. Single scope displays require another alternative set of work habits: habits not yet developed.

A third reason why our growth may be more leisurely is the motor ability of many of our present programmers. While a large majority of these personnel have had instruction and frequent access to both typewriters and keypunches, they have never achieved much proficiency with either. Thus their entry speed and accuracy will be the source of added expense and some frustration.

These three limitations will be with us even though the current price per user may be brought under control and the capital investment per individual served can be held to a manageable value. Thus, we have four major problems to be solved before remote terminal operation is warmly embraced.

Even though these limitations are removed, yet an additional technical problem exists. Whenever a single file can be accessed by more than one individual or whenever the contents of that file are the result of two or more uncoordinated updates, a severe audit trail and accountability problem will develop. This problem is doubly severe. There is no information

in the published literature which describes any current studies on this topic: planned or completed. Even when and if such studies are available, the problems within the Agency would amplify the difficulties involved, cause a complete review of the solutions, and probably would require some additional features not contemplated elsewhere. At this writing, the problem is as yet unstudied and must be faced soon and solved before the twin Model 67 is installed in first quarter 1967.

5.3.3. Fail-Soft Reconfiguration

Today it is common for many people in the computer field to speak quite glibly about computer based systems which gracefully degrade in the face of hardware outages. The only systems to date that fail-softly are some very expensive military command and control systems which do not handle the breadth of applications we contemplate, nor do they adhere to the budget constraints now impressed upon the Agency. In short, graceful degradation, fail-soft operation, and dynamic reconfigurations have never yet been successfully demonstrated in an industrial environment. The IBM Model 67 is reputed to enjoy these long sought attributes. The software according to preliminary specs is designed to complement the hardware

and allow near 100% availability with a minimum of manual intervention. When the detailed specs for this hardware and software are available, a study effort will be established to meticulously review them and to enumerate the conditions which can be tolerated and allow one computer to automatically survive, the conditions which can be tolerated provided prompt manual action is available, the conditions which cause temporary loss of the facility, and the conditions which cause an extensive period of down time. Hopefully, the latter case will not exist.

# Chapter 6.

# PERSONNEL TRAINING

## 6.1. MANAGEMENT TRAINING

Courses which emphasize the characteristics of the IBM 360 Model 67 are planned for management-level personnel. They will cover the operating system, remote terminal usage, scheduling of priorities, etc. Course #1, "Administrative Considerations of a Multi-Programming System" is scheduled for March 1966 for OCS management and supervisory personnel. This is scheduled for a repeat in November 1966. Agency personnel not in OCS but administratively responsible for remote terminal users of OCS hardware will be invited to attend either course. Further courses of this type will be offered on a continuing basis.

## 6.2. SYSTEM PROGRAMMER TRAINING

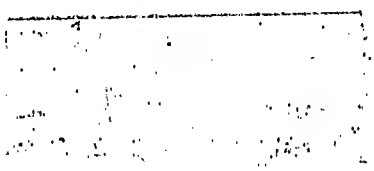
Eight programmers are currently assigned system programming duties. They will be the first personnel to be indoctrinated in System 360 and will acquire broad training in great depth. They will assist in the modification and installation of System 360 software in the Agency. They will act as in-house consultants to the applications programming staff, and they

will perform necessary modifications to the vendor-supplied software to adapt it to the unique needs of the Agency. Most training will be conducted either by the Chief, Technical Staff, or by consultants under his direction. These will be either short 2-4 hour seminars or extensive 2-5 day workshops.

One such workshop has already been held. In this four-day intensive session the design for a multi-utility program was set down. This program will allow the IBM Model 30 to operate several I/O devices concurrently as required. The experience gained in designing and constructing such an interleaved monitor program will be an invaluable base for our further work. The Model 30 will arrive in August 1965 and replace existing 1401 equipment; some of its time will be utilized for advanced system programmer training. In addition, supplementary training will be scheduled at various universities and at the manufacturer's education center as special courses are offered.

6.2.1. Tentative Schedule

The following tentative training schedule has been adopted.



SYSTEM PROGRAMMER TRAINING SCHEDULE

| COURSE NAME | 1Q65 | 2Q65 | 3Q65 | 4Q65 | 1Q66 | 2Q66 |
|---|---|---|---|---|---|---|
| Systems Design | 1 | | | | | |
| Direct Access Concepts | 1 | 6 | 2 | 1 | | |
| 360 Assembly | 5 | | 3 | 1 | 1 | |
| Compiler Languages | 3 | | | | | |
| Automatic Programming | 1 | | | | | |
| 360 COBOL | | 1 | 1 | | | |
| 360 FORTRAN | | 1 | | 1 | | |
| 360 PL/I | | | | 4 | 4 | 3 |
| 360 RPG | | | 1 | 1 | 1 | 2 |
| On-Line Computing Systems | 1 | | | | | |
| Time-Sharing | 2 | | | 2 | | |
| Advanced Multiprogramming Concepts | | | | | 8 | |
| Multiprocessing design and Throughput Evaluation | | | | | | 8 |
| Multiprogramming Monitor Design | | 7 | | | | |
| Query Languages and Communications | | | 2 | | | |
| Real-Time Programming | | 2 | | | | |

## 6.3. APPLICATIONS PROGRAMMER TRAINING

A planning effort is now underway to determine the best method for training the applications programmers. Unfortunately, the computer field has yet to adopt a standard glossary. Many of the terms have unique usages private to an individual vendor. Great benefit will result when only one vendor's equipment is installed and only one set of software is used. However, to achieve interchangeability of staff and scheduling flexibility, the existing compartments must be dissolved so that a common vocabulary, training, and expertise is shared by all personnel.

One approach to this is to offer three different series of courses appropriately tuned to the three backgrounds now prevalent in OCS. One course would be offered for programmers skilled in RCA equipment and techniques, one course would be offered for the character-oriented IBM programmers, and the third course would be offered to those experienced on binary-oriented IBM equipment. The first sessions of each of these three courses would be unique to the attendees' background experience. Naturally, the later sessions would be all identical.

In considering such a mode of retraining, considerable attention will be given to measuring the results of the training courses. In an attempt to offer a fair opportunity to all personnel regardless of prior background and in an attempt to objectively measure the quality of the training offered, some attempt will be made to measure the results of the course instruction.

A second approach to training is to exploit the individual courses offered by the vendor. IBM offers a striking variety of reasonably well prepared and adequately documented courses. Until the in-house courses are developed, personnel will be scheduled to attend vendor sessions as indicated on the following page. It should be noted that we are still providing training on existing equipment in order to support on-going operations prior to the installation of S/360. The importance of developing excellent training courses to allow the programmers to make the transition from earlier to very sophisticated equipment cannot be overemphasized.

6.3.1. Tentative Schedule

APPLICATIONS PROGRAMMER TRAINING SCHEDULE

| COURSE NAME | 1Q65 | 2Q65 | 3Q65 | 4Q65 | 1Q66 | 2Q66 |
|---|---|---|---|---|---|---|
| 1401 | 1 | 2 | | | | |
| 1410 | 1 | 1 | 1 | | | |
| Systems Design | | 4 | 9 | | | |
| Direct Access Concepts | 1 | 15 | 25 | 9 | | |
| 360 RPG | | | | 1 | | |
| 360 Assembly | 1 | 11 | 31 | 8 | 10 | |
| 360 COBOL | 1 | 10 | 5 | 7 | | |
| 360 FORTRAN | | 1 | 1 | | | |
| 360 PL/I | | | | 8 | 35 | 21 |

Chapter 7.

# REPROGRAMMING

The computer programs now used within the Center will need review and eventual reprogramming if they are to continue to be of use following the installation of IBM 360 equipment. The S/360 equipment is unique in the computer field in that the instruction decoding within the main frame hardware is implemented using a special technique which involves a read-only storage element. All of the control circuits are controlled by this read-only storage elements to implement the standard instruction set. The original motivation for this design was economy of circuitry and related hardware. However, it is possible to outfit the computer with a second read-only storage element which will cause the S/360 to interpret and decode a second, completely different, set of machine instructions.

The Agency S/360 will be outfitted with a second read-only store causing the S/360 to execute machine language instructions originally intended for a 7090 to be executed, without change, on the System 360. A performance penalty is paid only when this emulator feature is in use. Thus, if a

program's usage is expected to be extensive, the program will still need to be converted. However, through the use of the emulator, it will be possible to stretch out the effort required for program conversion so that the required effort and the available supply of trained manpower more closely approximate each other.

With the exception of the temporary emulator capability for 7090 programs, all existing computer programs will require conversion if they are to be used after the existing hardware is released. In preparation for such conversion activity, several steps may be taken. The programmers will be encouraged to bring their documentation up to date and to prepare current flow charts, program descriptions, table definitions, file specifications, and operators' writeups. Furthermore, special test packages may be prepared which consist of a set of data, a description of that data, a description of the processing the data requires, a set of outputs from the operating program, and annotations on that set of outputs. In addition, the programmers will be supervised so that any special programming techniques or complex sections or code are thoroughly documented and enable the conversion process to proceed with relative ease.

Programs written in machine language are the most difficult to convert. They usually require a manual rewrite of the entire procedure. Programs written in assembly language have some hope of being automatically translated into a language suitable for S/360 provided they do not make special use of unique features available exclusively on current equipment. Programs written totally in a compiler language can be converted automatically to the equivalent compiler language for input to S/360 through the use of a series of programs colloquially known as "SIFT" programs. A SIFT reads the program prepared for current equipment and translates those statements it can to equivalent statements suitable for the new equipment and flags those statements which require manual attention.

Utility programs can be prepared for present equipment which will ease the conversion process by searching out language constructions which are difficult, impossible, or inefficient to translate. Similarly, utility programs can be written for S/360 which will locate and tabulate statements which require further manual attention. An automatically-translated program seldom exploits the capabilities of the new equipment. This statement is even more true when the new equipment offers advanced data management and direct access storage devices. Thus, even when completely automatic translation is possible, the resulting code will need manual review to reduce excessive running times.

## 7.1. SCIENTIFIC COMPUTING

The scientific programs have been completely reviewed. There will be 47 programs which will be in continuing use after S/360 is installed. Of these, 19 will be completely rewritten by Agency staff members. Agency staff members will sift, review, and check out 28 others. The programming languages currently in use are MAP, FAP, FORTRAN II, and FORTRAN IV. Some of the FAP programs make use of IOCS. It is estimated that 21 man-months will be required to convert the scientific programs assuming we can get the documentation we require from the organizations which originally furnished the programs, such as JPL, NSA, and NBS. Outside contractual support may be needed to convert programs with inadequate documentation.

## 7.2. INTELLIGENCE DATA PROCESSING

The intelligence data processing programs have been completely reviewed. There will be 9 applications which will be in continuing use after S/360 is installed. One of these will use the 7090 emulator, another uses only OCS written general purpose programs. The other 7 applications, and the general purpose programs, will be completely rewritten by Agency staff members. The programming languages they will use will be a combination of 360 Assembly Language and COBOL. It is estimated that 28 man-months will be required to convert these intelligence data processing programs.

## 7.3. MANAGEMENT DATA PROCESSING

The applications in the management data processing area have been completely reviewed. There will be 7 individual applications in continuing use after S/360 is installed. In addition a single, large-scale Management Information System is being designed which will replace or obsolete the other management data systems currently being processed. These applications will be written using BAL, PL-I, and COBOL. It is estimated that 262 man-months will be required to accomplish this programming effort. To do this will require either an increase in staff personnel or outside contractor support or a combination thereof.

## 7.4. COMMUNICATIONS OPERATIONS SUPPORT

The supporting programs for communications operations have been completely reviewed. There will be 8 applications in continuing use after S/360 is installed. One of these is in FORTRAN II and may be sifted, reviewed, and checked out. The other four will be rewritten in COBOL. It is estimated that 7 man-months will be required to accomplish this effort.

## 7.5. STATISTICAL DATA PROCESSING

The programs in the statistical area have been reviewed. There will be 7 applications in continuing use after S/360 is installed. Three of them are in FORTRAN II and may be sifted, reviewed, and re-checked out. The other four will be rewritten in COBOL. It is estimated that 11 man-months will be required to accomplish this effort.

# Chapter 8.

# FILE CONVERSION

Information files are stored at the present time either in punched-card form, magnetic tape form, or a combination of the two. In addition, the magnetic tapes are prepared for both the RCA equipment and the IBM equipment. The planned life of these files will need evaluation and, if they will be used after the release date of the currently installed hardware, they will require conversion.

## 8.1. PUNCHED-CARD FILES

Approximately 1,200,000 punched cards are stored by OCS. Many of these contain standard BCD data which can be easily read by the proposed equipment. Others contain information which will be obsolete before the current equipment is released. The remainder are duplicates of magnetic tape files discussed below. From an initial analysis it appears that the conversion of punched card files will be a trivial problem.

## 8.2. MAGNETIC TAPE FILES

### 8.2.1. RCA Tapes

The RCA tapes cannot be used on the IBM tape drives. At the present time we have 2,252 RCA tapes in inventory.

From an initial analysis it appears that only 800 of these tapes will be required after the RCA equipment is returned.

An IBM compatible tape drive has been ordered for the RCA 301. After this device has been installed the 301 will be able to read an RCA tape and rewrite the same information on the IBM compatible drive. Following this step, the IBM compatible drive can be entered into the conversion process outlined below. It is estimated that approximately 300 hours of machine time will be required for the translation from RCA to IBM.

8.2.2. IBM Tapes

The IBM file conversion is equally formidable. Several character sets are in use within the facility. The bit structure of alpha-numeric characters must be modified for the S/360 and then translated from seven-track tape to nine-track tape. In addition, some files will require a subsequent sort so that they will again be in the collating sequence of the proposed equipment. The file conversion problem can be broken into eight categories. These categories, and the conversion processes to be followed, are outline below:

| Categories of Tape Files | How Converted |
|---|---|
| A, B | IBM Utility Programs are available. However, OCS has written a multi- |

| Categories of Tape Files | How Converted |
|---|---|
| | task tape file conversion program which can convert approximately 30% of these files using the initial Model 30. This same program can run as a background program to other processing, it will be the preferred conversion method. |
| C | No conversion in initial stages while emulating. Later converted to 9-track by OCS written program, (if file not obsolete). |
| D | Very probable that file will become obsolete. (Otherwise, use OCS program.) |
| E | File seldom used, probably program will be emulated with no conversion. |
| F | Tapes come from special equipment, non-standard and difficult to process. An inefficient conversion is possible using OCS |

written program, however, source equipment should be modified. This will be investigated further.

G — Systems tapes, will not be used on IBM 360, except under emulation. No conversion anticipated.

H — RCA tapes are not compatible with IBM hardware. An IBM compatible tape unit is being installed on the RCA 301. After this hardware compatibility conversion step, tapes will be considered as category A.

## 8.3. CURRENT INVENTORY

At present, there are 4,017 tapes in active use. An inventory of these tapes, broken down by category, follows:

| Type | Description | Category | Number |
|---|---|---|---|
| IBM | Form 1 (non standard min. rec size = 1) | D | 29 |
| IBM | Form 2 | A | 770 |
| IBM | Form 3 | A | 37 |
| IBM | Form 4 | A | 255 |

| Type | Description | Category | Number |
|---|---|---|---|
| IBM | FORTRAN Binary (Standard) | B | 379 |
| IBM | Binary (No Control Count) | C | 11 |
| IBM | Binary (Control record with decrement count) | E | 23 |
| IBM | Binary (Control record with counts and other identification information) | C | 19 |
| IBM | Binary (Control records with unidentified information, other data is binary integers) | C | 7 |
| IBM | Binary stream data with no Gaps | F | 3 |
| IBM | Binary, with BCD counts in 24 bit word increments | C | 8 |
| IBM | Binary, data with 1 integer per 6 bits records in multiples of 24 bit words. | C | 100 |
| IBM | 7090 Systems Tapes<br>1) binary<br>2) straight core image<br>3) col binary image<br>4) row binary image<br>5) mixed BCD and col binary | G | 92 |
| IBM | 1401 System Tape Odd Parity BCD, form 1 | G | 4 |

| Type | Description | Category | Number |
|---|---|---|---|
| IBM | 1410 System Tape Odd Parity BCD, form 1 | G | 28 |
| RCA | BCD, form 4 | H | 2190 |
| RCA | BCD, form 1 | H | 62 |
| | | TOTAL | 4017 |

8.4. CONVERSION SUMMARY

Of the 4017 tapes in use, 2723 need not be converted. They are either duplicates of tapes which will be converted or files which will be obsolete at the time conversion takes place. As can be seen in the following table, only a few files with nonstandard formats will need to be converted. It is estimated that only two or three man-months of programming effort will be required to prepare programs for this effort. The machine-time hours are summarized below:

| Cat | Substantive (Reels) | Hrs. | Resort (Reels) | Hrs. | Direct Access (Reels) | Hrs. | Hrs. |
|---|---|---|---|---|---|---|---|
| A | 600 | 86 | 90 | 45 | 550 | 110 | 241 |
| B | 300 | 43 | | | 100 | 20 | 63 |
| C | 30 | 4 | | | | | 4 |
| F | 3 | 1 | | | | | 1 |
| H | 800 | 114 | 46 | 23 | 750 | 150 | 287 |
| | | | | | | TOTAL | 596 |

# Chapter 9.

## CONTINUING DEVELOPMENTS

Of the projects now underway, two large efforts will continue to undergo change and evolution during the period when current hardware is released and the new S/360 is installed. Project CHIVE is a large scale document/information retrieval system under evolutionary development in the Agency. The Automated Language Processing system has been under contract for several years and the initial equipment deliveries are scheduled for installation and operation in October 1965.

### 9.1. DOCUMENT/INFORMATION RETRIEVAL

At the present time, installed computer equipment is being used for exploratory studies. No large production retrieval runs are being made. The period of exploration is drawing to a close and it is predicted that the developmental efforts will use 26 hours of 7090 time per month in third quarter 1965. Starting in early 1966 the project will have matured sufficiently so that the master data base can be constructed. This data base is currently estimated to involve 300,000,000 bytes of information in 1969. Today the file does not exist in automated form. To build such a huge file is an awesome undertaking. It requires hardware of extremely high reliability

with an exceptionally low cost per byte of information stored.

The proposed hardware system provides a Data Cell exclusively for the CHIVE retrieval files. In the interim, magnetic tapes will retain information after the file is read and edited. Starting in 1968, remote console interrogation equipment will also be required on an operational basis. The hardware system proposed, and the software schedules provided, will allow this large file to be interrogated using time-sharing techniques without an appreciable slowing of the background job currently in process.

It should be noted that IBM 360 has a storage device capable of holding the required data volumes required by this project.

Given storage of sufficient volume, it would be possible to dedicate a single isolated computer to the task of waiting for an inquiry, searching the file, and formatting the response. However, it should be noted that this solution would be uneconomical to the Agency since the computing capacity of the dedicated computer would not be available for other purposes. Using the time-sharing techniques proposed, it is estimated that the retrieval query and response processing will total only two hours per day on one model 67 after the system is in full operation.

## 9.2. LANGUAGE PROCESSING

For several years the Agency has followed developments pioneered by the IBM Corporation in the development of language translation hardware. A key device in this effort is the ALP Processor which is built around a unique read-only photostore memory which holds dictionaries and other lexographic material. The ALP Processor in turn feeds information to a general purpose computer for additional processing.

The special purpose equipment will be delivered and installed in fourth quarter 1965. An IBM 1401 computer will be obtained and dedicated to this development effort. Assuming the equipment and techniques prove out, the 1401 will be returned to the manufacturer on or about September 1966 and the special purpose ALP Processor will be connected to the 360/65 then installed within OCS. Similar time-sharing techniques will be applied to allow the Model 65 to perform commercial and scientific computations whenever its facilities are not required to support the ALP project. When the ALP equipment is inactive, 100 per cent of the Model 65's computational power will be available for other purposes. When the ALP equipment is in use, short sequences (sometimes amounting to only a few milliseconds) of CPU time will be used as required.

It is estimated that the sum total of these little bursts of computation will amount to one half hour per day in the first quarter 1967.

This support makes use of both the multiplexing channel of S/360 and the standard hardware interrupt system. Without these two features, a whole computer would be dedicated while the ALP equipment was in operation.

# Chapter 10.

## CHANGEOVER SCHEDULE

The plan for transition from the present heterogeneous OCS hardware/software complex to the monolithic system proposed for the Second Quarter 1967 is firm. The transition to this objective acquired several intermediate steps. Even though the schedule is firm, minor modifications will be made in specific features or components or in dates if the production requirements so demand. For example, the plan calls for the IBM 7090 to be replaced with an IBM 360/65 with no time overlap. Of course, this is contingent on the prior thorough testing and 100% compatible performance of the 7090 emulator on the Mod 65.

### 10.1. INSTALLATION SCHEDULE

The 28 individual events shown on the following schedule are considered management milestones. Naturally, many other intermediate checkpoints will occur between these major milestones. Of particular significance to the Technical Staff are the preparation and/or verification of the four control programs discussed in Section 5.2.2. The successful operation of these programs are prerequisites to the milestones listed below.

Since the various language processors of System 360 are independent of the control programs, the applications work force can proceed to prepare programs; the applications work force can prepare programs in the languages indicated below without fear of having these programs obsoleted by control program changes. In some cases, such as the processing of inquiries from remote consoles, it will be necessary to prepare substitute macros if it is desired to start checkout prior to the availability of certain control program features. When such macros are prepared, it will be possible to program and checkout applications programs which will, to a great extent, be independent of the schedules for control programs. After the control programs and the hardware have been thoroughly checked, the ersatz macros can be replaced by active routines and the console capabilities will be available through the simple process of reassembly.

INSTALLATION SCHEDULE

| MILESTONE | TARGET DATE | ACTIVITY |
|---|---|---|
| 1. | August 1964 | FORTRAN II programming discontinued. All new programming in FORTRAN IV. |

| MILESTONE | TARGET DATE | ACTIVITY |
|---|---|---|
| 2. | December 1964 | 1401 AUTOCODER programming discontinued. All new work in 360 assembly language. |
| 3. | July 1965 | 1410 mainframe converted to 7010. |
| 4. | August 1965 | 7010 AUTOCODER programming discontinued. All new work in 7010 COBOL. |
| 5. | August 1965 | Rearrange machine room in preparation for ALP equipment & Model 30. |
| 6. | September 1965 | ALP equipment received from vendor. Model 30 installed. |
| 7. | September 1965 | Programming support for 1401 AUTOCODER discontinued. |
| 8. | November 1965 | Peripheral 1401 returned to manufacturer. Additional plotter equipment installed. |
| 9. | February 1966 | FAP/MAP programming discontinued. All new work in FORTRAN IV or PL/I. |
| 10. | February 1966 | 7090 COBOL retired. All new work in 360 COBOL or PL/I. |
| 11. | February 1966 | Programming support for 7090 COBOL discontinued. |
| 12. | March 1966 | S/360 Model 65 received. 7090 returned to manufacturer. |
| 13. | April 1966 | 7090 FORTRAN IV programming discontinued. New work in 360 FORTRAN or PL/I. |

| MILESTONE | TARGET DATE | ACTIVITY |
|---|---|---|
| 14. | April 1966 | Beckman A/D equipment received. |
| 15. | July 1966 | 7010 COBOL programming discontinued. New work in 360 COBOL or PL/I. |
| 16. | July 1966 | 501 EZCODE programming discontinued. New work in 360 COBOL or PL/I. |
| 17. | July 1966 | RCA 301 Code programming discontinued. New work in 360 COBOL or PL/I. |
| 18. | September 1966 | ALP on-line to Model 65. ALP 1401 returned to manufacturer. |
| 19. | October 1966 | 7010 AUTOCODER Programs converted to PL/I. |
| 20. | November 1966 | 7010 COBOL Programs converted to 360 COBOL or PL/I. |
| 21. | November 1966 | 7010 returned to the manufacturer. |
| 22. | December 1966 | 7090 FORTRAN II programs converted to 360 FORTRAN or PL/I. |
| 23. | January 1967 | 7090 FORTRAN IV programs converted to 360 FORTRAN or PL/I. |
| 24. | February 1967 | 7090 FAP/MAP programs converted to PL/I. |
| 25. | March 1967 | Twin Model 67's received. Models 30 and 65 returned to manufacturer. |
| 26. | May 1967 | RCA 301 returned to manufacturer. |

| MILESTONE | TARGET DATE | ACTIVITY |
|---|---|---|
| 27. | May 1967 | RCA 501 declared surplus. |
| 28. | May 1967 | RCA 301/501 programming discontinued. |

10.2 PHYSICAL ARRANGEMENTS

To accomplish the hardware transformations indicated in the previous section, eleven hardware events will take place. Although some crowding will take place and temporary operational dislocations will result, the hardware events planned can take place completely within the confines of the present CIA Computer Center. As shown on the following table, the air conditioning and KVA loads will vary throughout this process. Based on available preliminary information, no additional air conditioning or power capacity will be required although minor changes and adjustments will be necessary to provide cooling where the heat is generated and receptacles where the power is required.

| | Event Date | Event | Air Condit. BTU/Hr | Power KVA |
|---|---|---|---|---|
| 1. | Jun 65 | None (presently Installed Computers) | 349,000 | 135 |
| 2. | Jul 65 | Convert IBM 1410 System to IBM 7010 System and provide space for ALP System. | 354,000 | 138 |
| 3. | Aug 65 | Move IBM 1401 System, Cal-Comp Plotter, and IBM 7090 for IBM 360/30 installation | 354,000 | 138 |
| 4. | Sep 65 | Install IBM/360/30 and ALP | 478,000 | 187 |
| 5. | Nov 65 | Remove IBM 1401 System and Temporary Installation; Install Benson-Lehner Plotter. | 411,000 | 158 |
| 6. | Mar 65 | Remove IBM 7090; Install 360/65 | 560,000 | 218 |
| 7. | Apr 66 | Install Beckman A/D System | 585,000 | 228 |
| 8. | Nov 66 | Connect ALP to 360/65; Remove IBM 7010 System | 489,000 | 182 |
| 9. | Mar 67 | Install IBM 360/67 System Remove IBM 360/30 | 700,000 | 259 |
| 10. | May 67 | Remove RCA 301 System | 675,000 | 251 |
| 11. | May 67 | Remove RCA 501 System | 612,000 | 229 |

# Chapter 11.

# BIBLIOGRAPHY

During the course of this study, several supporting investigations and studies were performed. These are in the OCS administrative files for the use of interested parties. They are described below.

## 11.1. ADVANCED (THIRD GENERATION) HARDWARE AND SOFTWARE TECHNOLOGY

Describes the terminology, hardware and software considerations necessary in a multi-time-sharing system. Discusses I/O and computing methods, concepts of remote user terminals, fail soft, fail safe, and memory protect features of new technology. Third generation micro-electronics, random access hardware, bulk core, and CRT display systems are discussed. A general discussion of methods and considerations in reprogramming for a new computer system is given.

## 11.2. COMPETITIVE HARDWARE EVALUATION

Computes the relative efficiency of competitive computer systems. Introduces, very briefly, 16 separate computer systems and evaluates the efficiency of these systems against the IBM 7094. Provides efficiency factors based on cycle time, add time, and cost to arrive at relative cost-efficiency

factors. Comparative computer hours required to accomplish two different work loads are presented for 24 old and new computer systems.

11.3 PHYSICAL PLAN FOR COMPUTER EQUIPMENT

Physical plan for hardware installation describes the floor plan, power, and air conditioning required for the central computer room from its current configuration until the final installation of the multi-processor IBM 360 installation in 1967. Considers all known hardware additions, substitutions and deletions during this time period.

11.4 CURRENT UTILIZATION AND COSTS

Study of the OCS computer center's hardware utilization and costs. Gives data on computer use time for various agency "customers" and graphs total utilization by computer system.

11.5 TRAINING REQUIREMENTS

Provides individual training schedules required to prepare all programmers and operators for the IBM 360 system. Some 20 courses are listed. Schedules list courses to be taken by each individual by calendar year quarters.

11.6 RENT VERSUS PURCHASE CONSIDERATIONS

The rent and purchase cost factors are in terms of the estimated retention period for each hardware component during the evolution of advanced computer system.